DOCUMENT RESUME

ED 219 744 CS 006 783

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TITLE Hypothesis Testing in Reading Comprehension. Technical Report #14.
INSTITUTION Columbia Univ., New York, N.Y. Teachers College.
SPONS AGENCY Department of Education, Washington, DC.
PUB DATE 81
CONTRACT 300-77-0491
NOTE 34p.

EDRS PRICE MF01/PC02 Plus Postage.
DESCRIPTORS *Cognitive Processes; *Conceptual Tempo; Hypothesis Testing; *Learning Theories; Prior Learning; *Reading Comprehension; Reading Processes; *Reading Research; *Schemata (Cognition)
IDENTIFIERS *Text Learning

ABSTRACT

The efficient reader constructs tentative hypotheses about the meaning of the text that has been read and about the content yet to come. The hypotheses remain tentative until all related information has been accounted for. The reader then constructs a model that considers all of the details in a text. If a promising interpretation fails to account for some aspect of the text, the reader can accept the interpretation in spite of its flaws or reject it and search for other interpretations. Research in schema theory as a framework for recall of information in text has lead to two views of text comprehension, one holding that it is a top-down or conceptually driven process, another proposing that reading is a bottom-up or data driven process. Experiments indicate that there are differences in cognitive style among children, based on how impulsively or reflectively they process information and on how much they rely on either top-down or bottom-up processing. It is important that a reader develop the ability to differentiate important from unimportant information in text. Use of appropriate schemata becomes the basis for recalling information that is most relevant to the central idea in a text. (Author/FL)

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HYPOTHESIS TESTING IN READING COMPREHENSION

Susan Kimmel and Walter H. MacGinitie

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Technical Report #14

1981

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Abstract

In order to derive meaning from text the reader undergoes an active process of construction based on the formulation and testing of various hypotheses. The efficient reader constructs tentative hypotheses about the meaning of the text that has been read and about the content yet to come. The hypotheses remain tentative until all of the related information has been accounted for. The reader then constructs a plausible model that takes into account all of the details in the text. If a promising interpretation fails to account for some aspect of the text, the reader can accept the interpretation in spite of its flaws or reject it and search for other plausible interpretations.

The literature in schema theory as a framework for recall of information in text has led to a consideration of the reading process from the same perspective. One view of text comprehension is that it is a top-down or conceptually-driven process. Another view proposes that reading is a bottom-up or data-driven process.

Experiments seem to indicate that there are differences in cognitive style among children, based on how impulsively or reflectively they process information and on how much they rely on either top-down (knowledge-based) processing or bottom-up (text-based) processing. It is important that a reader develop the ability to differentiate important from unimportant information in text. Utilization of appropriate schemata becomes the basis for recalling information that is most relevant to the central idea in a text.

HYPOTHESIS TESTING IN READING COMPREHENSION

Susan Kimmel and Walter H. MacGinitie

The reading comprehension process has been viewed in recent literature within a framework of hypothesis testing (Collins, Brown & Larkin, 1980; Rubin, 1977). That is to say, in order to derive meaning from text the reader must construct tentative hypotheses for what the material will be about. The reader must go through an active process of evaluation and test out various possible interpretations of the text. The reader must finally construct a plausible model that takes into account all of the details in the text. If a promising interpretation fails to account for some aspect of the text, the reader has the options of accepting the interpretation as adequate in spite of its flaws or rejecting it as inadequate and searching for other possible interpretations. Thus, a basic process in reading comprehension is testing of plausible hypotheses or evaluation of goodness of fit. A reader comprehends a text when he or she is able to find a configuration of hypotheses which offers a coherent account for all of the different aspects of the text. To the degree that a reader fails to find such a set of hypotheses, the text will seem incomprehensible.

The model that a reader constructs for a text is based upon utilization of what has been termed "schemata" in the literature on information processing. A schema is an abstract description of a thing or an event. It characterizes the typical relationship among its components and it contains a slot for each component that can be instantiated (Pichert & Anderson, 1977). Schemata exist for generalized concepts that underlie

objects, situations, and events. A schema contains the network of interrelations that is believed generally to hold among the constituents of the concept. We say that a schema "accounts for" a situation whenever the situation can be interpreted as an instance of the schema (Rumelhart & Ortony, 1977). Interpreting a message, according to schema theory, involves a matching of information in the message to the slots in the schema. The information entered into the slots is said to be subsumed by the schema. In a study by Pichert and Anderson (1977), college students were asked to take different perspectives on a story. One passage that the subjects were asked to read was a story about two boys playing hooky from school who decide to explore one of their homes. The subjects were all asked to read the same story, but one third of them were instructed to read the story from the perspective of a potential home-buyer, one third were asked to read it from the perspective of a burglar, and one third were given no special perspective. The authors proposed that a burglary schema would contain a loot subschema. Since the mention of three bicycles and Dad's famous paintings in the story could be considered loot, the authors hypothesized that these items were likely to be entered into slots in the loot subschema and become part of the instantiated representation in memory for the story. On the other hand, the leaky roof mentioned in the passage cannot be understood in terms of a loot subschema (or other subschemata related to a burglary). There does not appear to be a slot anywhere in a burglary schema that might contain information about a roof that leaks. It therefore does not fit into the representation in memory that would be constructed according to a burglary schema.

The general form of this theory of information processing is that high-level schemata provide the "ideational scaffolding" (Ausubel, 1963)

for anchoring elements in text. Whether or not a detail will be sufficiently processed in order to be remembered depends upon whether there is a niche for it in the structure. In line with this reasoning, the effects of perspective found by Pichert and Anderson (1977) were a result of different high-level schemata providing slots for the different kinds of information contained in the text.

Schemata as a Basis for Focusing on Important Text Information

It is important that a reader develop the ability to differentiate important from unimportant information in text. Utilization of an appropriate set of schemata becomes the basis for an efficient reader's facility in focusing on and recalling information that is most relevant to the central theme in a text. The process of separating out what is important from what is less important is a first step in the construction of an appropriate model for a text.

Research has shown that mature readers are able to distinguish important elements in text (Johnson, 1970; Meyer & McConkie, 1973; Bower, 1976). Although a variety of techniques and procedures have been used in these studies, investigators have demonstrated a high degree of agreement among adults concerning those portions of a passage that are most important, somewhat less important, and those which are unimportant to the theme of the story. Procedures for assessing importance have been quite varied. They include story grammars (Rummelhart, 1977), analysis of logical structure (Meyer, 1975), student rating (Johnson, 1970) and others. Bower (1977) used three procedures to determine which propositions in stories were important to the plot. In Bower's study, propositions that the story grammar assigned to the top level of a heirarchy were rated as

more structurally important. In addition, information that was perceived as central to the theme of the story was more likely to be mentioned in summaries.

At what age and in what ways does the processing bias toward important elements of text manifest itself? Investigations concerning children's ability to identify, to learn, and to remember the important elements of a text provide some clues, but the evidence is difficult to interpret. Some studies have shown that children's ability to identify or abstract main ideas is very limited and develops quite slowly (Brown, Smiley & Lawton, 1977). Danner (1976) found that young children can perform the task only when intense instruction is provided. Stein and Glenn (1977) suggest that categories of information that children consider important to remember are variable and change with age.

Some studies argue that children, like adults, favor important elements in recall. This argument was made as early as the turn of the century by Binet and Henri (cited in Thieman & Brewer, 1978) and Thorndike (1917), and more recently by Brown and Smiley (1977) and Christie and Schumacher (1975). Brown and Smiley had groups aged 8, 10, 12, and 18, rate the parts, or idea units, of two Japanese children's stories in terms of their importance to the structure and theme of the passage. The subjects were asked to eliminate one quarter of the idea units which they judged to be least important. This procedure was repeated twice more until only one quarter of the units, those judged most important, remained. The results showed that younger subjects did not differentiate structural importance, but older subjects (college students and, to some extent, seventh graders) did. Brown and Smiley then tested recall of the two stories at grades three, five, and seven. Older children recalled more

than younger, but all children followed, in general, the adult pattern of recall. That is, more of the highest rated idea units were recalled than those rated medium or low in importance. Even though they could not consistently identify the most important idea units, children recalled them most frequently.

The conclusion one can draw from studies on differentiating important from unimportant information from text is that in both identification and recall, sensitivity to importance seems to increase with age. The developmental trend suggests that while third graders tend to recall more important information, it is not until about sixth or seventh grade that children begin to show the adult pattern of importance ratings. It is noteworthy that these developmental studies of sensitivity to importance were done using narrative texts. There has been little investigation of such developmental trends for expository material.

It is interesting to consider why important elements are better recalled. Proposed explanations fall into two groups: those operating at the time a passage is encoded, and those that operate when it is retrieved. One encoding explanation suggests that subjects, after identifying important elements, direct to them greater amounts of cognitive processing. A different approach argues that subjects encode prose by using text elements to fill the slots in pre-existing knowledge frames. Material is important and better remembered if it fills the available slots. (Rumelhart, 1980; Anderson, Spiro & Anderson, 1977).

Several investigators (Bower, 1977; Mandler & Johnson, 1977; Pichert & Anderson, 1977) have proposed that importance has effects at retrieval, instead of, or in addition to, those at encoding. One argument is that memory search proceeds from the knowledge incorporated in pre-existing

knowledge frames to the particular information stored when the text was read. Information important to the knowledge frame would be accessible, while unimportant details would not. Another possible retrieval process is inferential reconstruction. Failing to recall a particular text element, a subject might try to reconstruct it on the basis of details which would usually fill slots in the knowledge frame. Anderson and Pichert (1978) attempted to distinguish processing that operates during retrieval from processing that operates during the initial reading of textual material. After recalling the burglar/homebuyer passage once, adult subjects were instructed to shift perspectives and then were asked to recall the story again. Subjects then recalled more information that was important to the second perspective than they had recalled at first. The data seemed to show the operation of retrieval processes as independent from encoding processes.

Subjects' self reports often supported the idea that high level knowledge structures guided memory search. They said that the new perspective led them to recall new information by causing them to think of the general category subsuming this information. Pichert and Anderson (1979), who replicated this perspective-shift study with third, fifth, and seventh grade children, found that the strategies used by children were similar to those used by adults. The children could flexibly change the schema that they were using to understand the story. The subjects in this study who could report on what they did to change their schema indicated that a new perspective made them think of the story in a new way, but most of the children could not clearly describe what was happening in their thinking that enabled them to recall more details following a shift in perspective. There has been little investigation of

the cognitive processes involved in shifting an interpretation of a text.

Schema Directed Processing as a Framework for Comprehension

The literature in schema theory as a framework for recall of information in text has led to a consideration of the reading comprehension process from the same point of view. One view of the comprehension of text is that it is a top-down, or conceptually-driven, process (Adams & Collins, 1977; Anderson, Spiro & Anderson, 1977; Ausubel, 1963). Rather than analyzing a text component by component, the reader formulates possible hypotheses for the meaning of the text and undergoes a process of accepting or rejecting those hypotheses. According to this view, reading is conceived of as a "psycholinguistic guessing game" (Goodman, 1976). The reader's expectations about the content of a text represent a form of preprocessing which should make subsequent analysis more efficient.

Another view of reading comprehension proposes that reading is a bottom-up, or data-driven, process (Gough, 1972; Bobrow & Norman, 1975). According to this theory, there is a series of discrete processing stages, each corresponding to a level of linguistic analysis. The analysis proceeds from the most primitive level to the most complex level. First, feature analyzers discriminate between horizontal, vertical, and oblique line segments, open and closed loops, intersection with a horizontal plane, etc. From this feature analysis letters are identified. Strings of letters are then analyzed into clusters from which words are recognized. Strings of words are parsed into phrases. Eventually a semantic interpretation of a sentence is produced. Sentence meaning is conceived to be

the product of the lower order levels of analysis, and the meaning of the text consists of the building up of the meanings of the component sentences.

To be sure, it is difficult to view the reading process as either completely data driven or conceptually driven. Rumelhart (1976) has presented a persuasive case that reading must involve continuous interactions among many levels of analysis. In what Rumelhart terms "schema directed" processing, activation goes in both directions. Schema directed processing proceeds in the following manner: An event occurs at the sensory system. The occurrence of this event automatically activates certain low level schemata that might be termed feature detectors. These low level schemata would, in turn, activate in a data-driven fashion the most applicable of the higher level schemata, of which they are constituents. These higher level schemata would then initiate conceptually driven processing, by activating the sub-schemata not already activated, in an attempt to evaluate their goodness of fit.

At some point, when one of these higher level schemata begins to get further positive results about its goodness of fit (i.e. it found evidence for others of its constituents) it would activate still higher level schemata which would look for still larger constituents. These higher, more abstract schemata would then activate, from the top-down, still other constituent schemata, and this activation would flow back down. The lower level schemata would eventually make contact with either other schemata which have been activated from the bottom-up, or initiate a search for the predicted sensory inputs.

Whenever sensory data predicted by a schema are not found, that counts as evidence against that schema. When sufficient evidence is

built up against a schema, processing of that schema is suspended and processing resources are allocated to other more promising hypotheses. Whenever enough evidence is gained in favor of a schema, that schema is taken as an adequate account, and the interpretation offered by the schema is taken as the correct interpretation for the event. Later processing, however, based on other higher level schemata, may eventually disconfirm a temporarily accepted schema. It is this type of flexibility that is important during the process of comprehension. It is important that a schema that proves to be incorrect be rejected and a new one formulated when necessary.

Rumelhart (1980) illustrates his theory of schema activation with the following example:

> Business had been slow since the oil crisis. Nobody seemed to want anything really elegant anymore. Suddenly the door opened and a well dressed man entered the showroom floor. John put on his friendliest and most sincere expression and walked toward the man.

Rumelhart found that most people generate a rather clear interpretation of this story. It is apparent that John is a car salesman down on his luck. He probably sells rather large, elegant cars. Suddenly a good prospect enters the showroom where John works. John wants to make a sale. To do that he must make a good impression on the man. Therefore, he tries to be friendly and act sincere. Presumably, had the story continued, John would have made the sales pitch and might have sold the man a new car.

It is proposed that, as the sentences were read to the adult subjects in this study, various schemata were activated, evaluated, and either refined or discarded. When the subjects were asked to describe their hypotheses as they read through the story, a consistent pattern of

hypothesis generation and evaluation emerged. The first sentence was usually interpreted to mean that business is slow because of the oil crisis. Thus, people were led to see the story as about a business which is somehow dependent upon oil. Many of Rumelhart's subjects hypothesized that the story would involve either the selling of cars or of gasoline. A few interpreted the sentence as being about the economy in general. The second sentence, about people not wanting elegant things anymore, led people with the gas station hypothesis to question their original interpretation. But even though elegance did not fit in with a gas station, that hypothesis was not always rejected. On the other hand, people with hypotheses about the general economy had no difficulty incorporating this sentence into their emerging interpretation. According to Rumelhart, the third sentence clinches the car interpretation for nearly all readers. They are already looking for a business interpretation, and when a well dressed man enters he is immediately labeled as a prospective buyer. The phrase "showroom floor" clearly invalidates the gas station interpretation and strongly implicates automobile sales. Finally, with the introduction of John, there is an ideal candidate for the salesman.

The process of comprehension is very much like the process of constructing a theory. The theory is then tested against the data currently available, and as more data become available, the theory is specified further. If the model that has been constructed leaves too many gaps, it is given up and a new one is formulated. Alternatively, if a new theory presents itself that seems to fit more of the data, then the old one is dropped and the new one accepted.

Through experience, we have built up a very large repertoire of schemata from which we construct an appropriate interpretation for a

text (Schank & Abelson, 1975; Bobrow & Collins, 1975; Anderson, Spiro & Anderson, 1977). We have, related to the example above, schemata for salesmen and the kinds of motives they have. We have schemata for automobiles, including how and where they might be sold. We have built up schemata for the oil crisis and what kinds of effects it has on people and businesses. The knowledge embedded in these schemata forms the framework for our theories. According to this view of reading comprehension, it is some configuration of these schemata that ultimately forms the basis for our understanding.

Collins, Brown and Larkin (1980) have discussed, from the perspective of means-end analysis, the theory that reading comprehension involves a process of hypothesis formation and evaluation. They propose that text understanding proceeds by progressive refinement from an initial model to more and more refined models of the text. The target structure guides the construction process, constraining the models to the class of well-formed, goal-subgoal structures that means-end analysis produces. This type of analysis puts certain constraints on the permissible structures that interrelate events in a text. The initial model is a partial model, constructed from schemata triggered by the beginning elements of the text. Successive models incorporate more and more elements of the text. The models are progressively refined by trying to fill the unspecified slots in each model as it is constructed. As the questions associated with the unfilled slots in more refined models become more and more specified, the search for relevant information is more and more constrained. The overall process is one of constraint satisfaction (Fikes, 1970; Waltz, 1975).

The literature in schema theory as a basis for comprehension

points to three possible reasons for a reader's failure to comprehend a text. First, the reader may not have the appropriate schemata. In this situation, the reader simply cannot understand the concept being communicated. Second, the reader may have the appropriate schemata, but the clues given by the author may not be sufficient to suggest them. Here again, the reader will not understand the text; however, with appropriate additional cues, he or she will come to understand it. Third, the reader may find an interpretation that is consistent with the text but is not the one intended by the author. In this situation, the reader will have made sense of the text but will, in fact, have misunderstood the author.

Bransford and Johnson (1973) studied the comprehension of texts in which the subjects lacked the appropriate schemata, ones in which the schemata were potentially available, but without enough clues to suggest them, and ones in which the subjects were led to choose a wrong interpretation. The following passage was used in one of these studies:

> The procedure is actually quite simple. First you arrange things into different groups. Of course, one pile may be sufficient depending on how much there is to do. If you have to go somewhere else due to lack of facilities that is the next step, otherwise you are pretty well set. It is important not to overdo things. That is, it is better to do too few things at once than too many. In the short run this may not seem important but complications can easily arise. A mistake can be expensive as well. At first the whole procedure will seem complicated. Soon, however, it will become just another fact of life. It is difficult to forsee any end to the necessity for this task in the immediate future, but then one can never tell. After the procedure is completed one arranges the materials into different groups again. Then they can be put into their appropriate places. Eventually they will be used once more and the whole cycle will then have to be repeated. However, that is part of life.

Most readers found this passage very difficult to understand. However, once the subjects were told that this passage is about washing clothes, they were able to apply their schemata for washing clothing and make sense out of the story. The difficulty with this passage was not that the readers didn't have the appropriate schemata. Rather, it was apparent that the clues in the story never suggested the appropriate schemata to begin with. The bottom-up information in this case is inadequate to initiate the comprehension process appropriately. Once the applicable schemata were suggested, however, the text was easily understood.

Interestingly, although most readers found the passage incomprehensible, some found alternative schemata to account for it and thus render it comprehensible. For example, a Washington bureaucrat had no difficulty with this story. He interpreted the passage as a clear description of his job. This individual, in an effort after meaning, had formulated a schema for pushing papers. This is an instance of the third type of comprehension failure that was discussed earlier in this paper. The reader understood the story, that is he made sense out of it, but did not construct the meaning intended by the author. In an attempt to find meaning, a poor reader will often create an interpretation for a text that is incorrect. He or she may even change aspects of the story in order that they may fit the original interpretation.

Development of Hypothesis Testing Behavior in Children

Research in concept attainment in children has demonstrated that a prerequisite to the formation of a concept is the ability to formulate and test hypotheses effectively. The ability to utilize hypotheses successfully

appears to increase with age. The developmental models of concept formation (Ingalls & Dickerson, 1969; Eimas, 1969, 1970; Shapson, 1970; Reiber, 1969) view concept attainment as resulting from the testing, in a trial-and-error fashion, of various predictions or hypotheses, similar to the process of reading comprehension outlined above. Theoretically, the subject selects a hypothesis from some set of hypotheses at the outset of a trial, and he or she responds on that trial in a manner consistent with the hypothesis selected. For example, in a sorting task a subject may predict that the blue stimulus is correct, regardless of its size or shape, or that the stimulus on the left is correct. If the subject receives feedback indicating that his or her response is correct, then he or she retains the hypothesis and responds in accordance with it on the succeeding trial. On the other hand, if the subject receives feedback indicating that the response is wrong, then he/or she abandons the hypothesis and selects a new one. The subject continues to test hypotheses until he or she selects one that results in no further errors. In this manner, the problem is solved and a concept is formed.

The child's ability to form appropriate hypotheses in the most efficient manner has been termed "focusing" by Bruner, Goodnow and Austin (1956). Focusing promotes the efficiency with which subjects use outcome information to eliminate incorrect hypotheses systematically. The ability to focus has been found in the literature to be strongly related to developmental level. Eimas (1969) found that second grade children showed almost no ability to focus beyond the first outcome trial. Ingalls and Dickerson (1969) showed that until children have reached the eighth grade there is no evidence of consistent focusing. In general, the research in

concept attainment shows that the older the child the more likely he or she is to formulate and use hypotheses correctly in any situation (Eimas, 1969; Ingalls & Dickerson, 1969; Reiber, 1969).

The formulation and testing of relevant hypotheses requires a flexible approach to a task. It is necessary that hypotheses be held tentatively, for they may need to be changed or discarded before a correct set of hypotheses is arrived at. Research has shown that the flexibility involved in changing inappropriate hypotheses becomes more efficient with age. Werner and Kaplan (1952), in their study of children's acquisition of word meanings through verbal contexts, proposed that the flexible evaluation of hypotheses becomes more successful as the child grows older. The authors suggest that a high degree of rigidity characterizes activity at a lower stage of development. In their study, subjects were given six sentence contexts as clues to the meaning of a nonsense word. The subjects were expected to arrive at the meaning of the word by going from one context to the other. Werner and Kaplan differentiated among several types of rigid behavior in approaching the solution of these tasks.

Werner and Kaplan's results showed a decrease in all types of rigid behavior with increase in age. They concluded from their study that a child reaches a more mature task attitude when he or she conceives of a solution as provisional or tentative. They emphasize a need for keeping a solution tentative until it is either confirmed or rejected by the cues from the subsequent text. It is reasonable to view some poor reader's inability to keep hypotheses tentative as a strategy that is immature.

Differences in Cognitive Style--Problem Solving Literature

Research in the area of problem solving has led to the theory that there are individual differences among children in their cognitive processing style. According to Kagan and Kogan (1970), problem solving consists of various processing stages which include encoding, memory, generation of hypotheses, evaluation of hypotheses, and deduction. Encoding is the process of recognizing information. Memory here refers to both short and long term functions as well as representation and retrieval. Generation of hypotheses is the production of alternative courses of action. Evaluation of a hypothesis defines how the child judges the product. The deduction phase is the child's implementation of the hypothesis.

The role of evaluation during the problem-solving process is of great importance. Research in this area has shown that the extent to which a child evaluates his or her hypotheses influences the quality of encoding, memory, presentation of alternative hypotheses, and the final cognitive product (Kagan & Kogan, 1970). The powerful influence of evaluation can be grasped through a better understanding of hypothesis generation. Kagan (1971) defined a hypothesis as an interpretation of a discrepant event accomplished by mentally transforming the unusual event to a form the child is familiar with. (This description is obviously congruent with the schema theory view of reading comprehension described earlier.) Throughout the evaluative process the child is attending to the stimuli, working at interpreting the events, and generating alternative hypotheses. Therefore, during the evaluation of alternative hypotheses the child is constantly utilizing feedback information

from earlier problem-solving activities.

One variable in the evaluation process has been isolated and labeled the "reflectivity-impulsivity" dimension by Kagan (1971). Kagan has primarily used the Matching Familiar Figures Test to differentiate impulsive and reflective children. In this test the child is shown a standard figure and six variants, only one of which is exactly like the standard. The child is asked to select the one figure that is a replica of the standard. If incorrect on first choice, the subject is asked to select again until correct. The reflective child is defined as one who is below the median in errors but above the median in reaction time first choice, while the impulsive child is above the median errors but below the median in reaction time.

The relationship between this reflectivity-impulsivity dimension and cognitive or problem-solving strategy has been the object of several studies. Nuessle (1972) found that older and more reflective children were better processors of information and proposed that a reflective cognitive style facilitates effective hypothesis evaluation and problem solution.

One reason that reflectivity is associated with better information processing could be that reflective children analyze more important or relevant features of stimuli. Support for this position is found in the research of Odom, McIntyre, and Neal (1971) and Siegel, Kirasic, and Kilburg (1973). They found that reflective children perceived and evaluated information using more detailed feature analyses of stimuli than did impulsive children.

It may also be that reflective children are better information processors because of the manner in which they evaluate alternatives.

Denney (1973) presented evidence suggesting that reflective children tend to ask more constraint-seeking questions. That is, they ask questions that seek to eliminate possible alternatives. McKinney (1973) found significant differences in conceptual strategy between reflective and impulsive children. The reflective children in McKinney's study generated more efficient hypothesis-testing kinds of strategies. Reflective children appeared to consider several alternative hypotheses and used a strategy that tested the relevance of conceptual categories rather than specific instances. Impulsive children were less likely to form abstract hypotheses and more often used information idiosyncratically.

Kagan, Rosman, Day, Albert and Phillips (1964) characterized the impulsive method of problem solving as associated with anxiety from repeated failure. The impulsive child is apt to act upon his initial hunch with minimal reflection, carry through a false hypothesis mentally, and offer an answer without critical examination of its potential accuracy. These characteristics are consonant with observations of some children who have difficulty with text comprehension.

Differences in Cognitive Style--Reading Comprehension Literature

The research in reading comprehension has also suggested that there are differences in the cognitive processing styles of individuals. The theoretical framework guiding the research on differences in reading comprehension style characterizes reading comprehension as an interaction of text-based (or bottom-up) processes and processes related to existing knowledge schemata evoked by the text (top-down processes). Experiments seem to indicate that there may be differences among individuals in

their patterns of resource allocation to text-based versus knowledge-based processes (Spiro, 1979 a,b; Spiro & Tirre, 1979). According to this literature, skilled readers (both adult and child) tend to employ more processes in a preferred direction when characteristics of the situation permit processing in one direction to substitute for processing in the other without affecting ultimate performance. For poor readers, however, there appears to be a tendency to over-rely on processes in one direction, resulting in poor reading comprehension performance.

What causes some individuals to develop reading comprehension styles biased toward the text while others manifest a bias toward indulging their prior knowledge at the expense of attention to the text? The most obvious case of an over-reliance on the text in comprehension is the result of an absense of relevant knowledge structures to utilize in top-down processing. If the schemata do not exist, they cannot be used in text comprehension. However, schema availability alone is not a sufficient condition for adequate comprehension (Bransford & Johnson, 1973). Relevant schemata must be accessed. Differences between typical situations in which oral and written language are used suggest that schema accessibility might be a particular problem in comprehending written discourse. Oral language is typically embedded in a rich nonlinguistic context, which frequently signals the schemata that need to be activated. If not, the listener can ask for clarification. Written discourse, on the other hand, is relatively decontextualized. Clues to which schemata need to be activated must be obtained from the text alone.

The problem of schema activation is further complicated by the level of generality typical of children's knowledge structures. Schemata tend

initially to be tied to their context of acquisition, rather than achieving a generality allowing application to a wide range of similar situations (Nelson, 1977). A related problem concerns the use of schemata by analogy. We cannot have a pre-packaged knowledge structure for every situation. However, structural similarities can often be detected between domains that are well-represented in prior knowledge. In this case, existing knowledge structures may be transformed to fit the new domain.

Spiro (1979a) argues for a two-tiered approach to individual differences in reading comprehension. One tier involves the component skills in comprehension; the other is concerned with the manifestation of skill deficiencies in reading comprehension style. Confronted with a skill deficiency, two options are available to readers. They may persevere in the problem area or they may shift processing resources in an effort to compensate for the problem. For example, there are readers who decode laboriously but persevere with their decoding efforts. Given the limitations on information processing capacity, this behavior may produce a "bottleneck" in the system (Perfetti & Lesgold, 1978). The result may be that higher-order, more knowledge-based processes, will not be utilized. On the other hand, readers who decode laboriously may prefer to avoid the decoding task and rely on prior knowledge to guess what is likely to occur in the text. In other words, the same deficiency may lead to either a text-based or a knowledge-based comprehension style.

Some flexibility is frequently permitted in the relative contributions of the components of interactive processing. That is, in some situations one can compensate for schema-based processes by relying more on text-based processes and vice versa. For example, in recalling text

one can use the text's structural organization as a framework (Meyer, 1975), or, alternatively, the reader may supply schemata that can be used as scaffolding to facilitate recall (Anderson, Spiro & Anderson, 1977). However, too much emphasis on either processing style is usually not efficient.

Spiro and Tirre (1979) found that there are variations in the extent to which individuals utilize prior knowledge schemata. The Embedded Figures Tests (EFT) were used, since the authors assumed they would parallel the discourse processing requirements of operating with two structures simultaneously or in succession (a text structure and a knowledge structure). The EFT, which require detection of a memorized target shape embedded in a complex configuration, were considered to be analogous in processing characteristics to schema-based text processing in which a knowledge structure must be fit from memory onto the structure of the text. Spiro and Tirre predicted that high scorers on the test would demonstrate greater use of pre-existing knowledge schemata in a discourse processing task. They found that EFT score correlated with recall of more schema-relevant information from stories. In this study, neither the EFT used to differentiate the groups nor the recall task directly involved reading comprehension. More information needs to be obtained on differences in reading comprehension style utilizing reading material more directly.

Schema Change

Lack of flexibility in testing hypotheses can be detrimental to problem solving. Changing strategies in line with feedback information is necessary in order to arrive at the most efficient solution to a problem.

In a study comparing the problem solving strategies of schizophrenic and normal adults (Pishkin & Williams, 1977), the normal subjects proved to be better problem solvers since their strategy was characterized by frequent changing of hypotheses, even at early stages. The normal subjects tended to retain hypotheses that worked most frequently. When a solution was reached they would make no further changes. The schizophrenic subjects could not solve the problems, since they tended to hold on to one means of solution even if it was inconsistent with feedback information. Such rigid cognitive strategies are also common in brain injured and some learning disabled children (Strauss & Kephart, 1955; Strauss & Werner, 1942; Cratty, 1969).

In an analogous way, lack of flexibility can interfere with the efficient processing of information from text. In order to understand text, a set of hypotheses must be formulated at the outset that relates the information in the text to an appropriate schema. The hypotheses must remain tentative until all of the information in the text has been accounted for. If the original set of hypotheses fits all of the information in the text, then the reader must maintain the model throughout (Spiro, 1979b). However, if all of the details in the text cannot be accounted for in the set of hypotheses originally formulated, they must then be changed.

As a text proceeds, the knowledge schemata that can best be applied often change. Spiro (1979b) provides an example in a study of story processing with college students as subjects. In the text that was used in the study, an engaged couple discovers that their views differ on the issue of having children. They quarrel, but later in the story the couple

are happily married, though there has been no further mention of the quarrel over having children. Two schema states are left in conflict for the reader, one that anticipates disharmony and one that contradicts that expectation.

How do readers deal with such contradictions? One possibility is that conflicting states are allowed to co-exist. That is, need for reconciliation may be noted, but no specific reconciling information is incorporated into a retelling of the story. On the other hand, conflicting schemata may produce a state of cognitive disequilibrium with an impetus for reconciliation. In this case, elements in the story may be distorted or new information may be imported to provide reconciliation of the conflicting schemata. The co-existence and accommodative reconstruction hypotheses were tested by Spiro (in press). Stories like the one about the engaged couple were presented to adult subjects. They were instructed to recall the story as exactly as possible. The results provided support for the accommodative reconstruction hypothesis, rather than co-existence. That is, people tend to provide explanations for a change in schema. In their recalls, subjects tended to add information that would explain how the disagreement was resolved. For example, the subjects in the study "recalled" such importations as that the couple had received counseling on their problem, had decided to adopt a child, or did not really disagree very strongly about having children to begin with. The Spiro experiments related to schema change imply that adult readers require justification for changing schemata. The recalls of the story about the engaged couple demonstrated that readers provided their own justification for the change in schemata, since there wasn't enough provided in the story.

Changes in schemata are often necessary during the reading process. Many times the hypothesis that is formulated at the outset no longer fits. Kintsch (1979) also discusses the need for flexibility in changing schemata. In his model of the reading comprehension process, propositions are grouped in terms of the "facts" to which they belong. Once a fact is established, it generates expectations about other information in the text. An appropriate knowledge structure is pulled out of the reader's knowledge store and the text propositions are related to that knowledge structure. Kintsch illustrates that a knowledge structure must not only be activated at appropriate times but, in many cases, must be revised while reading.

An experiment by Bruner and Potter (1964) illustrates the negative effect of premature commitment to a particular schema. In their study, subjects were presented with slides of familiar objects that were out of focus. The slides were brought into focus incrementally. At each step along the way, subjects were asked to make a guess as to what the slide was a picture of. Many subjects mis-identified the slide at the beginning, became committed to their early interpretations, and remained inflexible. It seemed that the earlier the subject became committed to an interpretation, the more information was required to disconfirm the original hypothesis. It is quite plausible that a commitment to a hypothesis early in the reading process causes the reader to require much more disconfirming information before he or she is willing to change or disregard the hypothesis.

Conclusion

The literature on reading comprehension has been examined within a framework of hypothesis testing. A reader must develop a model for the meaning of a text that takes into account all of the information presented. The model is developed utilizing various hypotheses that are evaluated and either accepted, revised, or rejected in favor of other more plausible hypotheses. The hypotheses that are formulated are based upon real world expectations about events, objects, places, etc., that would be included in a schema for a given situation.

It is important that we determine what it is that makes some readers fail to understand text. Of particular concern is the reader who seems to be able to apply schemata to a text, but does so inflexibly. That is, such a reader will construct a plausible interpretation for the meaning of a text but will perseverate in its application, even when further information makes a change necessary. Kintsch (1979), Spiro (1979a, 1979b) and others have discussed the necessity of changing schemata during the reading comprehension process.

The research done by Spiro and his colleagues on differences in reading comprehension style (top-down versus bottom-up) and the research in the area of differences in cognitive processing styles (reflective versus impulsive) has begun to focus on individual differences among readers. However, such categories are too broad to be maximally effective in helping children improve their skills in reading. It is necessary that specific types of reading comprehension problems be isolated and understood.

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